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AN EXPERIMENTAL STUDY OF BENTHIC ALGAL STANDING CROPS IN THE LEESTON DRAIN, CANTERBURY

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ABSTRACT

Benthic algal standing crops were investigated in a small Canterbury stream by measuring levels of chlorophyll a and phaeophytin on greywacke blocks placed on the substrate between July 1972 and April 1973. Blocks were placed at 4 stations differing in nutrient enrichment and degree of shading. Chlorophyll levels fluctuated considerably at all stations and were not consistently higher at the nutrient enriched sites. Factors affecting standing crop biomass are discussed; these include light intensity, species composition, silt deposition and invertebrate grazing.

INTRODUCTION

Benthic algae, or periphyton, often make a significant contribution to primary production in streams. Artificial substrates have provided one means of studying lotic primary production and their use has been discussed critically by a number of workers e.g. Sladecekova (1962), Wetzel (1965) and Kevern *et al.* (1966).

This paper presents the results of a study in which uniform stone substrates were used to measure periphyton standing crops as chlorophyll a and phaeophytin a in an organically enriched stream. Chlorophyll values provide a measure of the living algal component of the periphyton whereas phaeophytins, which are degraded chlorophylls, provide a measure of the dead algal material. Together they give an estimate of periphyton biomass but this cannot be converted accurately to dry weight of algae since the chlorophyll content of an algal cell may vary seasonally or in relation to light intensity, and the ratio pigment : cell biomass differs according to species. Ideally, biomass

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data should be supported by information on the taxonomic composition of the periphyton: however, this was not done in the present study.

STUDY AREA AND METHODS

The study was carried out in the Leeston drain on the Canterbury Plains. Four sites were used: Stations 1 (43°47'25"S, 172°20'23"E) and 2 (43°47'17"S, 172°20'20"E) were within Harts Creek Wildlife Reserve near the mouth of the drain. Station 3 (43°45'36"S, 172°18'23"E) was immediately below the township of Leeston and Station 4 (43°45'31"S, 172°17'6"E) was 1 km below the spring source of the stream. Stations 1 and 3 were subject to mild organic enrichment whereas Stations 2 and 4 were not enriched (Table 1).

TABLE 1. SELECTED WATER QUALITY PARAMETERS MEASURED AT FOUR SITES IN THE LEESTON DRAIN.
Figures shown are the mean monthly measurements taken during the period of the experiment (24 July 1972 to 8 April 1973) (see Marshall 1974).

Station	1	2	3	4
BOD_5 ($g m^{-3}$)	4.2	1.9	5.1	2.6
PO_4 - P (mg m^{-3})	33	13	55	15
NO_3 - N (g m^{-3})	1.0	1.4	3.3	3.6
NO_2 - N (mg m^{-3})	13	16	70	11
NH_3 - N (mg m^{-3})	200	20	120	2.0
Water temperature (°C)	14.6	14.7	16.1	16.1
pH	7.1	7.2	7.4	7.6

Greywacke stones (the natural substrate of the Leeston drain) were cut with a diamond saw into small blocks with an exposed area of 3200 mm^2 available for algal colonisation. Six blocks were placed in a triangular frame (Fig. 1) which was buried in the substrate so that the blocks protruded 10 mm above the stream bed. This simulated the orientation

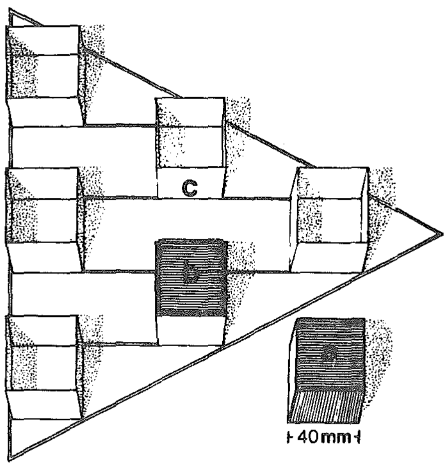

Fig. 1. Metal frame for holding cut greywacke blocks in the stream bed. a = single block; b = block in position; c = triangular frame.

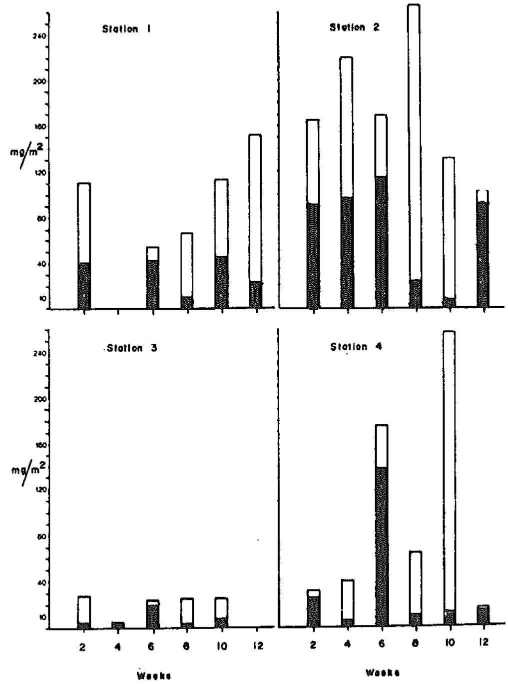

Fig. 2 24 Jul. 1972 -
25 Oct. 1972

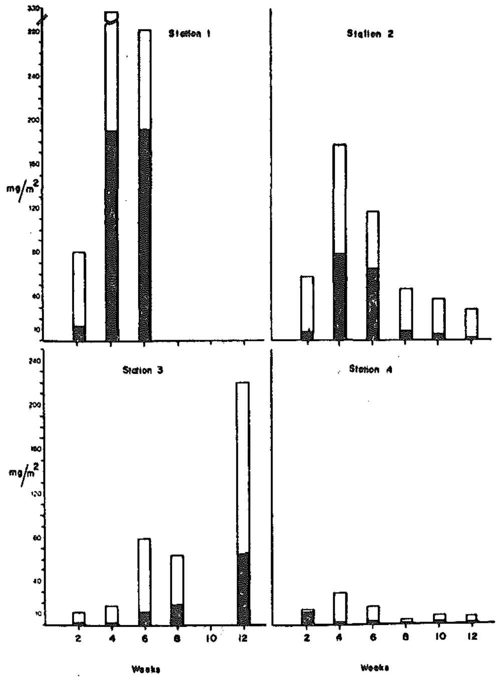

Fig. 3 25 Oct. 1972 -
15 Jan. 1973

Figs 2-4. Accumulation of chlorophyll a and phaeophytin a (mg/m^2) at 4 locations in the Leeston Drain (shaded = chl. a, non-shaded = phaeophytin a).

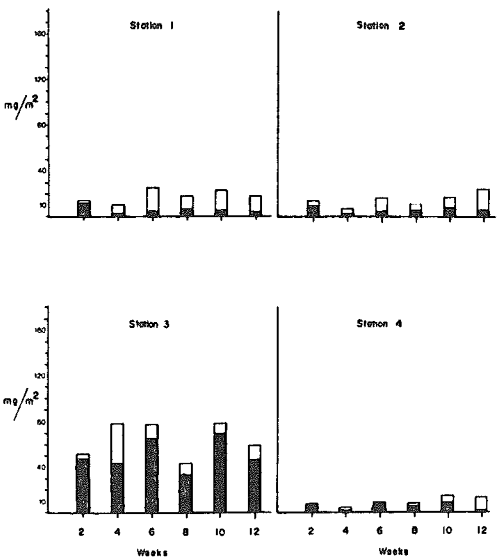

Fig. 4 15 Jan, 1973 -
8 Apr. 1973

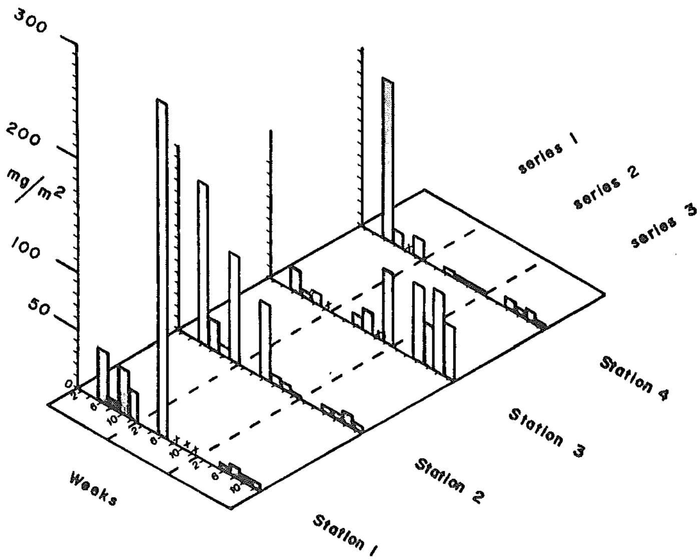

Fig. 5. Seasonal fluctuations in chlorophyll a levels (from series 1-3) at four stations in the Leeston drain between 24/7/72 and 8/4/73. (X = lost samples).

of the substrate of the stream bed. Duplicate sets of holding frames and blocks were placed at each station. Because the number of blocks was limited, the experiment was run in three series each of approximately three months. Two blocks were removed from each station every 14 days. Pigments were extracted in freshly redistilled 90% acetone in the dark for 24 h at 4°C. The extracted solution was centrifuged and absorbancy of the supernatant fluid measured. Chlorophyll a and phaeophytin a concentrations were measured according to Moss (1967a, 1967b).

RESULTS

SERIES 1. This series was run from 24 July to 25 October 1972 (Fig. 2). Chlorophyll a, phaeophytin a and total pigment concentrations fluctuated considerably and irregularly from week to week. Chlorophyll and phaeophytin levels were consistently lowest at Station 3 where shading and silt deposition were greatest. On most sampling days pigment levels were highest at Station 2.

SERIES 2. This series was set up on 25 October and ran through spring and early summer until 15 January 1973 (Fig. 3). At Station 1 chlorophyll a concentration increased rapidly to 190 mg. m^{-2} by week 6. Theft of the blocks prevented further measurements being made but observations of algae on surrounding shingle suggested that standing crop would have remained high.

At Station 2 a rapid build up of chlorophyll a occurred in the first 4 weeks (up to 78 $mg.m^{-2}$) but it declined to very low levels by the end of the experimental period. In contrast, chlorophyll concentration at Station 3 increased steadily over the 12 weeks to a maximum of 65 $mg.m^{-2}$. Little chlorophyll was detected at Station 4 (1-12 $mg.m^{-2}$) throughout the 12 weeks. On most sampling days phaeophytin levels were higher than chlorophyll levels at all stations but they showed no clear pattern of increase or decline.

SERIES 3. This series was run from 15 January to 8 April 1973 (Fig. 4). Chlorophyll concentrations were low (less than 10 $mg.m^{-2}$) and relatively uniform on all sampling days at Stations 1, 2 and 4. Phaeophytin levels were a little higher in most weeks at Stations 1 and 2 but slightly lower than chlorophyll concentrations (except in week 12) at Station 4. Chlorophyll levels recorded at Station 3 were up to seven times higher than those attained at the other stations. Levels >35 $mg.m^{-2}$ occurred in all weeks but phaeophytin levels were always lower.

SEASONAL FLUCTUATIONS IN ALGAL STANDING CROP

Chlorophyll a levels recorded on each sampling day of Series 1-3 (excluding values obtained in the initial growth phase - first 4 weeks) are combined in Fig. 5 to show seasonal changes in "living biomass" of the benthic algal community.

At Station 1 algal biomass was highest in early summer and declined in late summer and early autumn. At the most highly enriched station (Station 3) algal standing crop was lower than at Station 1 in spring and early summer when the stream bed was shaded by heavy macrophyte growths. However, a higher level was attained in late summer and autumn.

A different pattern was found at the non enriched stations 2 and 4 where there was a build-up of chlorophyll a in winter when mats of filamentous algae developed. These algae were sloughed off in spring and replaced by encrusting forms, primarily unicellular diatoms, which have a much lower chlorophyll content, and persisted throughout summer.

DISCUSSION

Two of the most obvious factors affecting algal growth in streams are water temperature and light intensity. Water temperature was similar at all stations on each sampling day and had an annual range from 7°C to 25°C (Marshall 1974). No positive correlation was found between algal standing crop (as indicated by chlorophyll concentration) and water temperature and in fact, different seasonal patterns occurred at different stations.

The stations differed in degree of shading, the stream bed at Station 3 being most heavily shaded (by a hedge, marginal vegetation and aquatic macrophytes), Station 1 having intermediate conditions whereas Stations 2 and 4 were most open to the sun and lacked extensive macrophyte beds. During winter, Station 3 supported little algal growth whereas Stations 2 and 4 had much higher chlorophyll levels. However, during summer Station 3 was much less shaded and the algal standing crop was higher than at Stations 2 and 4. These results suggest that light intensity was one factor affecting periphyton standing crop. In addition, differences in standing crop may have been due to the presence of different algal assemblages which are likely to possess varying responses to light (Hynes 1970).

Other factors which might be expected to affect algal standing crops are nutrient levels, invertebrate grazing and silt deposition. Wilhm and Long (1969) and Cooper and Wilhm (1970) found that algal biomass and chlorophyll levels increased faster and reached higher levels under higher nutrient conditions. In the Leeston drain, Station 3 had the highest phosphate and nitrate levels and Station 2 the lowest but chlorophyll concentrations were not consistently higher at Station 3. The high nutrient levels at Station 3 stimulated heavy growths of macrophytes however, and this presence greatly reduced light penetration to the stream bed. In addition, fine sediments were continually being deposited on the surfaces of stones at the two nutrient enriched stations, and may have reduced the suitability of the surfaces as sites for algal colonisation.

The effects of invertebrate grazing cannot be assessed. Kedhe and Wilhm (1972) considered the effects of invertebrate grazing upon stream periphyton production and demonstrated that at a density of 120 snails/m^2, chlorophyll a levels attained were greater than when snails were absent. They attributed this effect to the snails releasing bound nutrients which stimulated the growth of algae. In the Leeston drain, observed densities of the most abundant grazer, the gastropod, *Potamopyrgus antipodarum* (Gray) were up to 100 times greater than those considered by Kedhe and Wilhm (1972) (Marshall 1974). Therefore, while their grazing activities may stimulate algal growth, they may also reduce (limit) standing crop biomass.

In summary, it is clear that benthic algal standing crops (and presumably rates of primary production) in the Leeston drain are controlled by an interacting series of factors which vary seasonally and whose individual importance cannot be assessed by field work alone.

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